under the name of F3900/IM-7 or from Hercules Corp. under the name of 8551-7/IM-7. The preferred metallic foil is titanium alloy foil as previously described and the high strength metal members inserted into the dovetail root flank apertures are titanium alloy pins.

The method of forming a laminated airfoil using a polymeric composite layer rather than an elastomeric layer is similar to the method previously described. After accurately preshaping and trimming both the metallic foil and the uncured polymeric composite plies to a predetermined size, the metallic foils and polymeric composite plies are alternately assembled into a ply assembly in alternating layers with the metallic foil forming the first and last layers in the assembly so that the outer surfaces of the airfoil ply assembly are metal. This ply assembly is then inserted into the die cavity and compacted using sufficient heat and pressure to cause the polymeric composite matrix to flow, thereby simultaneously bonding the matrix o the polymeric composite to the metallic foil and curing the ply assembly into a finished or semi-finished airfoil. Optionally, a metal leading edge may be assembled to the ply assembly prior to insertion of the assembly into the die cavity. In this case, the cured airfoil will include a metal leading edge.

The cured airfoil is finished by drilling dovetail root aperture holes into the dovetail root flank surface and inserting adhesive-coated metal members through the apertures to provide additional strength. This operation is followed by final machining of the dovetail flank and by trimming operations, if necessary. A metal sheath **20**, usually of the same material as the metallic foil used in the ply assembly, is applied to the leading edge **16** of the blade using an adhesive, if this item was not cured with the airfoil assembly in the die. A typical adhesive is AF-163-2 which is an epoxy-based adhesive obtainable from the 3-M Company.

In the preferred embodiment using titanium alloy metallic foil, such as Ti-6Al-4V, and an uncured polymeric composite ply, such as F3900/IM-7, the ply assembly is placed in the die cavity and heated to a temperature of about 325°–375° F. at a pressure of about 100–200 psi for about 2 hours at temperature.

In still another embodiment of the present invention, as depicted in partial cross-section in FIG. **3**, the laminated airfoil as previously described is made from alternating layers of metallic foil **28**, polymeric composite ply **50** and an energy-absorbing elastomeric layer **30** to form a laminated composite airfoil assembly. In this embodiment, the elastomeric layer **30** is interposed between each layer of metallic foil **28** and polymeric composite ply **50** to join the metallic foil **28** to the polymeric composite ply **50**. Once again, the metallic foil **28** forms the first and last layers of the ply assembly so that the outer surface of the airfoil is metal.

The polymeric composite ply **50** comprises an intermediate modulus carbon fiber in a resin-based matrix of the type previously discussed, such as a F3900/IM-7 or 8551-7/IM-7. The elastomeric layer in the preferred embodiment is a modified adhesive film such as FM-300I or an epoxy adhesive film having a thermoplastic carrier, such as HXT-440, or a bis-maleimide adhesive film with thermoplastic carrier such as HXT-441. The metallic foil is selected from the group consisting of titanium or titanium alloys, nickel base superalloys and stainless steels and may be produced by superplastic forming. However, the preferred metallic foil is titanium alloy foil, Ti-6Al-4V, produced by superplastic forming. The method of forming the laminated airfoil using polymeric composite ply, metallic foil and an elastomeric adhesive is similar to the previously described methods of forming airfoils. The metallic foil **28** and the polymeric composite plies **50** are preshaped and accurately trimmed to a predetermined size. The metallic foil **28** and the polymeric composite plies **50** are then alternately layered into a laminated assembly, with elastomeric adhesive interposed between each piece of metallic foil **28** and polymeric composite plies **50**. The metallic foil forms the first and last layers of the assembly. The laminated assembly is then placed in a die cavity. Optionally, the metal sheath leading edge **20** may be assembled into the die with the laminated assembly in the manner previously discussed. The laminated assembly is then pressed in the die while applying sufficient heat and pressure to cause the elastomeric adhesive to flow thereby simultaneously bonding the polymeric composite matrix having embedded fibers to the metallic foil. The heat and pressure also cure the polymeric composite matrix. The cured airfoil is then removed from the die.

If necessary, the cured airfoil may be trimmed. Apertures **22** are drilled in the dovetail root flanks **14** and adhesive-coated titanium alloy pins are inserted into the apertures. A metal sheath, made from the same alloy as the metallic foil may be attached to the leading edge **16** of the airfoil using an epoxy adhesive, if the metal leading edge is not applied to the laminated airfoil assembly as part of the curing operation in the die.

In the preferred embodiment of this alternate assembly, the ply assembly is heated to a temperature of about 250°–350° F. and to a pressure of about 100–200 psi for about 2 hours. The laminated airfoil of the present invention is most useful as a wide chord fan blade in a turbine engine. The laminated airfoil of the present invention may also find use as a vane for the compressor section of a turbine engine.

Any of the composite airfoils of the present invention may be provided with an optional tip cap **60**, as shown in FIG. **4**. The tip cap **60** may be a standard formed cap made of titanium, titanium alloy or stainless steel. When a tip cap is provided, however, it is preferably of the same metal as that used in the blade assembly. Thus, in the preferred embodiment, the tip cap is superplastically formed Ti-6Al-4V. As is well-known in the turbine engine blade arts, any abrasive layer such as layer **62** in FIG. **4** may be applied to tip cap **60** to improve the abrasive wear characteristics of the blade as contact with the engine occurs during engine operation.

In light of the foregoing discussion, it will be apparent to those skilled in the art that the present invention is not limited to the embodiments, methods and compositions herein described. Numerous modifications, changes, substitutions and equivalents will now become apparent to those skilled in the art, all of which fall within the scope contemplated by the invention.

What is claimed is:

1. An energy absorbing, laminated airfoil having a tip portion, a dovetail root section, a leading edge extending from the tip portion to the root section, and a trailing edge oppositely disposed to the leading edge and extending from the tip portion to the root section, comprising:

alternating layers of a metallic foil and an elastomeric layer forming a laminated composite airfoil, the metallic foil forming the first and last layers,;